

CLAIMS

What is claimed is:

1. A flow control method for use in a wireless communication network wherein a Packet Core Network (PCN) supports data connections with one or more mobile stations, and wherein the packet core network transfers data as needed to a Radio Access Network (RAN) for delivery to individual ones of the mobile stations, the method comprising:

receiving a flow control on message at the PCN from the RAN indicating that flow control should be turned on for a mobile station;

turning flow control on for data connections associated with the mobile station and thereby suspending packet data transfers from the PCN to the RAN on those data connections; and

receiving a flow control off message at the PCN from the RAN indicating that flow control should be turned off for the mobile station; and

turning the flow control off for the data connections associated with the mobile station and thereby resuming packet data transfers as needed from the PCN to the RAN on those data connections.

2. The method of claim 1, wherein receiving a flow control on message at the PCN from the RAN indicating that flow control should be turned on for a mobile station comprises receiving an A11-Registration Request message at a Packet Data Serving Node (PDSN) of the PCN for the mobile station that includes a flow control indication.

3. The method of claim 2, wherein receiving an A11-Registration Request message at a Packet Data Serving Node (PDSN) of the PCN for the mobile station that includes a flow control indication comprises receiving an A11-Registration Request message for the mobile station that includes a Normal Vendor Specific Extension (NVSE) value indicating that flow control should be turned on for the mobile station.
4. The method of claim 1, wherein receiving a flow control off message at the PCN from the RAN indicating that flow control should be turned off for the mobile station comprises receiving an A11-Registration Request message at a Packet Data Serving Node (PDSN) of the PCN for the mobile station that does not include a flow control indication.
5. The method of claim 1, further comprising, at a Packet Control Function (PCF) of the RAN, receiving data on an existing data connection from the PCN for transfer to a targeted mobile station and, if the targeted mobile station is unavailable, sending a flow control on message to the PCN to cause the PCN to turn on flow control for the data connection.
6. The method of claim 5, further comprising, at the PCF, determining that the targeted mobile station has become available again, and sending a flow control off message to the PCN to cause the PCN to turn off flow control for the data connection.
7. The method of claim 6, wherein determining that the targeted mobile station has become available again comprises initiating by the PCF one or more transmissions to the targeted mobile station and determining whether the targeted mobile station timely responds to such transmissions.

8. The method of claim 7, wherein initiating by the PCF one or more transmissions to the targeted mobile station and determining whether the targeted mobile station timely responds to such transmissions comprises initiating at least one of initiating a paging attempt and initiating a short data delivery burst.

9. A method of flow control for use in a wireless communication network comprising a Packet Core Network (PCN) and a Radio Access Network (RAN), the method comprising:

receiving packet data at the RAN for delivery to a mobile station having an established data connection with the wireless communication network;
determining that the mobile station presently is unavailable for delivery of packet data; and
sending a first flow control message from the RAN to the PCN requesting the PCN to suspend transferring packet data to the RAN for the mobile station.

10. The method of claim 9, wherein receiving packet data at the RAN for delivery to a mobile station having an established data connection with the wireless communication network comprises receiving packet data at a Packet Control Function (PCF) included in the RAN sent from a Packet Data Serving Node (PDSN) included in the PCN.

11. The method of claim 10, wherein determining that the mobile station presently is unavailable for delivery of packet data comprises sending a service request for the mobile station from the PCF to an associated Base Station (BS) included in the RAN.

12. The method of claim 10, wherein sending a first flow control message from the RAN to the PCN requesting the PCN to suspend transferring packet data to the RAN for the mobile station comprises sending an A11-Registration Request message for the mobile station from the PCF to the PDSN that includes a flow control indication to cause the PDSN to turn flow control on for the mobile station.

13. The method of claim 12, further comprising suspending transfer of packet data from the PDSN to the PCF for the mobile station responsive to receiving the first flow control message at the PDSN.
14. The method of claim 13, further comprising, responsive to determining that the mobile station has become available again, sending a second flow control message from the PCF to the PDSN indicating that the PDSN can resume packet data transfers to the PCF for the mobile station.
15. The method of claim 14, further comprising resuming packet data transfers as needed from the PDSN to the PCF for the mobile station responsive to receiving the second flow control message at the PDSN.
16. The method of claim 12, further comprising:
 - determining that the mobile station has become available again; and
 - sending another A11-Registration Request message for the mobile station from the PCF to the PDSN, wherein the PCF omits the flow control indication to cause the PDSN to turn flow control off for the mobile station.
17. The method of claim 9, wherein receiving packet data at the RAN for delivery to a mobile station having an established data connection with the wireless communication network comprises receiving packet data at a Packet Control Function (PCF) of the RAN for delivery to a mobile station.

18. The method of claim 17, wherein determining that the mobile station presently is unavailable for delivery of packet data comprises sending a service request from the PCF to an associated Base Station (BS), such that a Mobile Switching Center (MSC) associated with the BS determines whether the mobile station is busy or is unresponsive to one or more paging attempts.
19. The method of claim 17, wherein determining that the mobile station presently is unavailable for delivery of packet data comprises initiating by the PCF a service request at an associated Base Station (BS) for the mobile station, starting a connection timer at the PCF, and determining whether the mobile station responds to the service request before expiration of the connection timer.
20. The method of claim 19, further comprising determining whether the mobile station has become available again by initiating one or more service requests at the PCF subsequent to sending the first flow control message.
21. The method of claim 20, further comprising maintaining an inactivity timer at the PCF to time the initiation of subsequent connection attempts.
22. The method of claim 9, wherein determining that the mobile station presently is unavailable for delivery of packet data comprises determining that the mobile station is unresponsive to one or more paging or short data burst delivery attempts by the RAN.
23. The method of claim 9, further comprising actively monitoring for a return to availability by the mobile station based on determining whether the mobile station responds to one or more RAN-initiated transmissions to it.

24. The method of claim 23, wherein actively monitoring for a return to availability by the mobile station based on determining whether the mobile station responds to one or more RAN-initiated transmissions to it comprises periodically paging the mobile station and determining whether it responds to any such pages.
25. The method of claim 23, wherein actively monitoring for a return to availability by the mobile station based on determining whether the mobile station responds to one or more RAN-initiated transmissions to it comprises periodically sending short data bursts to the mobile station and determining whether it acknowledges any such short data bursts.
26. The method of claim 9, further comprising limiting application of the flow control method to data connections associated with mobile stations that are always-on mobile stations.
27. The method of claim 9, further comprising, if the mobile station becomes available again before the PCN tears down the data connection, sending a second flow control message from the RAN to the PCN indicating that the PCN may resume sending packet data to the RAN for the mobile station.
28. The method of claim 9, further comprising determining that the mobile station has become available again, and sending a second flow control message from the RAN to the PCN indicating that the PCN may resume sending packet data to the RAN for the mobile station.

29. The method of claim 9, further comprising determining that the mobile station has become available again based on receiving a message at a Packet Control Function (PCF) included in the RAN that indicates the mobile station has re-registered with the wireless communication network.
30. The method of claim 29, further comprising, at a Mobile Switching Center (MSC) included in the RAN, determining whether a registration event involves a mobile station for which packet data transfers from the PCN to the RAN have been suspended and, if so, sending notification to a Base Station Controller (BSC) to indicate a return to availability by that mobile station, and wherein the BSC provides the message to the PCF indicating that the mobile station is available again responsive to receiving the notification from the MSC.
31. The method of claim 30, wherein determining whether a registration event involves a mobile station for which packet data transfers from the PCN to the RAN have been suspended comprises inspecting one or more flow control flags stored at the MSC.
32. The method of claim 31, further comprising setting flow control flags for particular mobile stations at the MSC responsive to receiving indications from the BSC that packet data transfers have been suspended for those particular mobile stations.
33. The method of claim 9, further comprising, at a Mobile Switching Center (MSC) included in the RAN, sending notifications of mobile station registration events to a Base Station Controller (BSC) to indicate availabilities of those mobile stations.

34. The method of claim 9, wherein determining that the mobile station presently is unavailable for delivery of packet data comprises sending a service request from the PCF to an associated Base Station Controller (BSC) included in the RAN and determining whether the RAN successfully establishes radio service for the mobile station.

35. The method of claim 9, wherein determining that the mobile station presently is unavailable for delivery of packet data comprises determining that no radio link can be established between the RAN and the mobile station.

36. The method of claim 9, wherein determining that the mobile station presently is unavailable for delivery of packet data comprises determining that the mobile station is busy.

37. A method of flow control in a wireless communication network comprising:
 - receiving data at a Packet Control Function (PCF) for delivery to a mobile station
 - having an established data connection with the network;
 - determining that the mobile station is unavailable for delivery of the data; and
 - sending a message to a Packet Data Serving Node (PDSN) requesting it to turn flow control on for the mobile station by suspending further transfers of data to the PCF for the mobile station.
38. The method of claim 37, further comprising:
 - determining that the mobile station has become available again; and
 - sending a message to the PDSN requesting it to turn flow control off for the mobile station by resuming transfers of data as needed to the PCF for the mobile station.
39. The method of claim 38, wherein the PCF requests the PDSN to suspend or resume transfers of data to the PCF for the mobile station based on including or omitting one or more flow control indications in defined registration messages generated by the PCF and sent to the PDSN.
40. The method of claim 38, wherein determining that the mobile station has become available again comprises receiving notification of a registration or origination event involving the mobile station.

41. The method of claim 38, wherein determining that the mobile station has become available again comprises sending a service request for the mobile station from the PCF to an associated Base Station Controller (BSC) included in the RAN and determining whether the RAN successfully establishes radio service for the mobile station.
42. The method of claim 37, wherein the PCF requests the PDSN to turn flow control on for the mobile station by including a data off indicator in a packet data registration message sent by the PCF to the PDSN for the mobile station.
43. The method of claim 42, wherein the PCF requests the PDSN to turn flow control off for the mobile station by not including the data off indicator in another packet data registration message sent by the PCF to the PDSN for the mobile station.
44. The method of claim 37, wherein receiving data at a Packet Control Function (PCF) for delivery to a mobile station having an established data connection with the network comprises receiving data for a dormant mobile station, and wherein determining that the mobile station is unavailable for delivery of the data comprises determining whether the dormant mobile station can be re-activated for delivery of the data.
45. The method of claim 44, wherein determining whether the dormant mobile station can be re-activated for delivery of the data comprises, if the mobile station is busy such that delivery of packet data is precluded, starting a reactivation timer at the PCF and, upon expiration of the reactivation timer, sending a service request for the mobile station from the PCF to an associated Base Station Controller (BSC).

46. The method of claim 44, wherein determining whether the dormant mobile station can be activated for delivery of the data comprises sending a service request for the mobile station to an associated Base Station Controller (BSC) and starting a connection timer and, if the dormant mobile station has not responded before expiration of the connection timer, determining that the dormant mobile station cannot be re-activated for delivery of the data.
47. The method of claim 46, further comprising starting an activation timer upon expiration of the connection timer to time a subsequent transmission of a service request from the PCF to the BSC and, if the dormant mobile station does not respond to the subsequent service request, sending one or more additional service requests according to periodic expirations of the activation timer.
48. The method of claim 37, further comprising sending notifications of mobile station registration events from a Mobile Switching Center (MSC) of the network to a Base Station Controller (BSC) associated with the PCF to apprise the PCF regarding the availability of mobile stations.
49. The method of claim 48, further comprising, at the PCF, sending a message to the PDSN requesting that it turn off flow control for a particular mobile station responsive to receiving a notification of registration for that particular mobile station via the BSC.

50. The method of claim 37, further comprising, at a Mobile Switching Center (MSC), determining that flow control is turned on for a particular mobile station responsive to recognizing that the mobile station has failed to respond to a paging attempt initiated by the MSC responsive to an associated Base Station (BS) service request for the mobile station.
51. The method of claim 50, further comprising storing one or more flow control flags at the MSC to identify which particular mobile stations supported by the MSC are flow-controlled mobile stations, and further comprising sending notifications of mobile station registrations involving any flow-controlled mobile station to a BSC associated with the PCF so that the PCF is apprised whenever any flow-controlled mobile station is involved in a registration event.

52. A Packet Data Serving Node (PDSN) for use in a wireless communication that includes a Packet Core Network (PCN) and a Radio Access Network (RAN), the PDSN comprising:

a packet data interface circuit configured to support packet data connections

between the PCN and one or more mobile stations supported by the RAN; and

a flow control circuit configured to turn flow control on for a mobile station by suspending transfer of data from the PDSN to the RAN on one or more data connections associated with the mobile station responsive to receiving a first flow control message from the RAN.

53. The PDSN of claim 52, wherein the flow control circuit is configured to turn flow control off for the mobile station and resume transfer of data as needed from the PDSN to the RAN on the one or more data connections associated with the mobile station responsive to receiving a second flow control message from the RAN.

54. The PDSN of claim 52, wherein the first flow control message indicates that the mobile station is unavailable for packet data delivery and the second flow control message indicates that the mobile station is available for packet data delivery.

55. The PDSN of claim 52, wherein the first and second flow control messages both are registration messages sent by one or more Packet Control Functions (PCFs) associated with the RAN, and wherein the PDSN is configured to determine whether any given registration message received from a PCF is a first or a second flow control message based on determining whether the given registration message includes a data off indicator.

56. The PDSN of claim 52, wherein the PDSN is configured to adjust its packet delivery accounting data for the mobile station based on receiving the first flow control message from the RAN.

57. A Packet Control Function (PCF) for use in a wireless communication that includes a Packet Core Network (PCN) and a Radio Access Network (RAN), the PCF comprising:

a packet data interface circuit configured to support packet data connections between the RAN and the PCN; and

a flow control circuit configured to request the PCN to suspend and resume data transfers as needed for one or more mobile station data connections based on the availability of those mobile stations for delivery of packet data.

58. The PCF of claim 57, wherein the PCF is configured to request the PCN to suspend data transfers for a particular mobile station by requesting that a Packet Data Serving Node (PDSN) at the PCN turn flow control on for that particular mobile station, and is configured to request the PCN to resume data transfers as needed for a particular mobile station by requesting that the PDSN turn flow control off for that particular mobile station.

59. The PCF of claim 58, wherein the PCF requests the PDSN to turn flow control on for a particular mobile station by sending a first flow control message and requests the PDSN to turn flow control off for that particular mobile station by sending a second flow control message.

60. The PCF of claim 58, wherein the PCF sends the first and second flow control messages to the PDSN as registration request messages but wherein it denotes a given registration request message as a first or second flow control message by including or not including, respectively, a data off indicator in the given registration request message.

61. The PCF of claim 57, wherein the PCF is configured to receive data from the PCN for delivery to a mobile station having an established data connection, and determine whether the mobile station is available for delivery of the data, and wherein the flow control circuit is configured to send a message requesting that the PCN suspend transfer of data to the PCF for the mobile station if the mobile station is unavailable.
62. The PCF of claim 61, wherein the PCF is configured to determine if the mobile station becomes available again, and wherein the flow control circuit is configured to send a message requesting the PCN to lift the suspension of data transfer for the mobile station if the mobile station becomes available again.
63. The PCF of claim 57, wherein the PCF is configured to determine whether a mobile station is available or unavailable by determining whether a radio link for the delivery of packet data can be timely established for the mobile station.
64. The PCF of claim 63, wherein the PCF is configured to determine whether a mobile station that previously was determined to be unavailable becomes available again, and to inform the PCN of that return to availability.
65. The PCF of claim 57, wherein, once the PCF requests the PCN to suspend data transfer for a particular mobile station, the PCF is configured to initiate one or more paging or short data delivery burst attempts for that particular mobile station to determine whether that particular mobile station has returned to availability.

66. The PCF of claim 65, wherein the flow control circuit includes an activation timer, and wherein the PCF is configured to initiate a paging attempt or a short data delivery attempt at each of one or more expiration intervals of the activation timer.